Variation of Short-Scale Waves in the Shoaling Zone

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LONG-TERM GOALS

Goals are to provide measurements of short-scale sea surface roughness in the shoaling wave zone, determine the correlation between this short-scale slope variance and surface wind stress, and finally suggest the ramifications to microwave remote sensing near the coast.

OBJECTIVES

Primary objective during SHOWEX is to define and understand the characteristics of near-vertical incidence millimeter-wave radar backscatter from wind waves over the surf zone and how it differs from wave scattering observed over the open ocean. Our approach utilizes aircraft radar and wind measurements collected from the NOAA Long-EZ. Observed radar information relates directly to an integration of the sea surface spectrum over wave scales from swell down to 1 cm but with heavy weighting towards cm-scale gravity capillary waves. These small wavelets are directly forced by the local wind. We have also demonstrated a new technique for measuring the slopes of the intermediate scale gravity waves using a three laser ranging system aboard the aircraft. Thus our studies have expanded to addressing the correlation between intermediate and short scale wave characteristics and the atmospheric turbulence data collected using the LongEZ. This work falls under the Shoaling Waves Research Initiative (SHOWEX) with Jielun Sun being the primary group leader.

APPROACH

A Ka-band scatterometer has been built and installed on the NOAA LongEZ research aircraft. High spatial resolution (< 1 m) radar backscatter data are being related to the small-scale surface slope using two-scale ocean scattering models. These measurements are highly complementary to the longer-wave slope data being derived from the LongEZ's laser sensors. Most importantly, the surface observations are taken in concert with precise atmospheric turbulence data using the LongEZ's gust probe. Combined, the data can describe the variability of wave slope variance in the coastal zone. Knowledge of the slope variance is vital to the investigation of air-sea coupling and to proper understanding of scatterometer, SAR and radiometer measurements of the ocean surface.

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WORK COMPLETED

NOAA's LongEZ flew more than 25 data missions during the Shoaling Waves Experiment (SHOWEX) conducted off of Duck N.C. in 1999. In 2000-2001 the radar and laser data analysis techniques have been refined leading to final products for the entire data set. Internal and external radar calibration work is complete. Three papers (see publication list) are completed, detailing the surface wave and atmospheric measurements and their coupling. Substantial effort has gone into attempts to extract directional long wave data from the LongEZ's 3 laser system – an effort that shows only limited promise. See the report of J. Sun for more on this topic. Radar data was presented at the SHOWEX workshop in May 2001 and collaborations with the NOAA Twin Otter's remote sensing investigations (Fedor, Irisov) are underway.

RESULTS

Studies listed below document three separate applications of the LongEZ data gleaned from the SHOWEX missions. Perhaps most relevant to SHOWEX, Sun et al. (2001) documents atmospheric turbulence near the coast and its variation with respect to on- and off-shore wind flow. The works listed have been discussed in past reports. Efforts in the present fiscal year are focused on combining in situ and aircraft data, collected over the course of 1997-1999 experiments, into one comprehensive data set. One primary new result revolves around the unexpected importance of the slope variance associated with intermediate scale waves, particularly within the coastal zone. These waves are shown to control much of the surface signature within the first 5-20 km from shore under offshore flow conditions. LongEZ laser altimeter data make these findings possible.

IMPACT/APPLICATIONS

The SHOWEX LongEZ Ka-band radar/laser/gust probe compilation is a comprehensive air-sea coupling data set. Our coastal wave coupling observations are expected to impact coastal wave modeling and flux estimation efforts, particularly those based on remote sensing techniques. Radar results, in preparation, document relatively minor change between Ka-band and the currently used Ku-band systems with respect to the effective Fresnel coefficient and electromagnetic bias components. This new information may impact future system designs.

TRANSITIONS

Ka-band radar results are being used in the design of the lightweight ALTIKA Ka-band radar altimeter system supported by NASA and CNES.

RELATED PROJECTS

Work is directly related to the NOAA LongEZ shoaling zone activities headed by J. Sun (cf. Sun:N00014-0-98-1-0245, Mahrt:N00014-0-98-1-0282, and Crawford:N00014-97-F-0123). This work is also closely related to NASA's Office of Earth Science research efforts to improve estimation of ocean sea level and wind speed as extracted from satellite altimeters, scatterometers and radiometers.

SUMMARY

The NOAA LongEZ affords the opportunity to sample the wind, humidity and temperature variations down near to the ocean surface (below 40 feet). The aircraft's extended and frequent flights over the Outer Banks during SHOWEX provided a large new data set for understanding the spatial varaiation in the wind flow over the surf zone and how this flow adjusts as it spreads over the open ocean. The present effort takes advantage of this platform by adding surface wave observations to the aircraft's capability. Our study of the surface wave dynamics in and beyond the shoaling wave zone are intended to instruct interpretation of satellite and aircraft radar data over similar targets. One specific focus of remaining studies is an improved definition of the surface wave field in the surf zone versus the open ocean using the compiled observations.

PUBLICATIONS

Vandemark, D., P. D. Mourad, T. L. Crawford, C. A. Vogel, J. Sun, S. A. Bailey and B. Chapron, Measured changes in ocean surface roughness due to atmospheric boundary layer rolls, J. Geophys. Res., 106(C3), 4639-4654, 2001.

Sun J. , D. Vandemark , L. Mahrt, D. Vickers, T. L. Crawford and C. A. Vogel, Momentum transfer over the coastal zone, J. Geophys. Res., 106(12), 12437-12448, 2001.

Chapron, B., D. Vandemark, and T. Elfouhaily, Measured and modeled steep ocean surface slopes, In Gas Transfer at Water Surfaces, edited by M. A. Donelan, W. M. Drennan, E.S. Saltzman and R. Wanninkhof, Nov. 2001.